REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)* 25 April 2003	**2. REPORT TYPE** Technical Abstract	**3. DATES COVERED** *(From - To)*
4. TITLE AND SUBTITLE **The Impact of Modeling Fidelity on Rocket Engine Performance**		**5a. CONTRACT NUMBER**
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Mark Archambault		**5d. PROJECT NUMBER** **3058**
		5e. TASK NUMBER **RF9A**
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Research Laboratory (AFMC) AFRL/PRSA 10 E. Saturn Blvd. Edwards AFB CA 93524-7680		**8. PERFORMING ORGANIZATION REPORT NUMBER** AFRL-PR-ED-AB-2003-112
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Research Laboratory (AFMC) AFRL/PRS 5 Pollux Drive Edwards AFB CA 93524-7048		**10. SPONSOR/MONITOR'S ACRONYM(S)**
		11. SPONSOR/MONITOR'S NUMBER(S) AFRL-PR-ED-AB-2003-112

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

20030616 044

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Sheila Benner
a. REPORT **Unclassified**	**b. ABSTRACT** **Unclassified**	**c. THIS PAGE** **Unclassified**	A		**19b. TELEPHONE NUMBER** *(include area code)* (661) 275-5693

FILE

MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO)

29 Apr 2003

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-AB-2003-112**
Mark Archambault (AFRL/PRSA), "The Impact of Modeling Fidelity on Rocket Engine Performance Parameters"

42nd Aerospace Sciences Meeting & Exhibit
(Reno, NV, 5-8 January 2004) (Deadline: 02 May 2003)

(Statement A)

The Impact of Modeling Fidelity on Rocket Engine Performance Parameters

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The overall objective of this research is to establish a design methodology for gas/gas injectors. This paper, however, focuses on a computational methodology to efficiently, accurately, and robustly obtain high-fidelity solutions of combusting rocket engine flows to gain a knowledge and understanding of their features. To that end, simulations of a single-element, shear-coaxial, H_2/O_2 engine are being performed to characterize its flowfield and to validate the CFD++ flow solver for this class of problems. Previous work has focused on obtaining solutions on a grid three to four times finer than those reported by other researchers and resolving numerical issues that reduce the computational efficiency of this inherently unsteady flow.[1-5] Comparisons of two-dimensional and three-dimensional steady and averaged time-accurate solutions have also shown that a steady solution may not provide an accurate depiction of the combusting flow field over time (Fig. 1).

Other simulations have shown[5,6] that flow features unique to an experimental configuration, such as a nitrogen curtain purge used to cool the optical access, can influence both the experimental and computational results. Figure 2 shows that when the nitrogen curtain purge present in the experiment is modeled, the predicted hydrogen profile is more consistent with the experimental data. This is due to the fact that when the nitrogen is present, the hydrogen is unable to radially diffuse to the engine walls as quickly as when the nitrogen is absent. It is clear that the nitrogen has had an influence on the experimental data and both the experimenter and the modeler should take care when interpreting their results.

The converging section of the nozzle and the throat were omitted in these previous studies while numerical issues associated with the calculations were resolved and because the region of interest was far upstream of the outlet. As a result, the previous studies did not report on parameters to rocket engine designers such as specific impulse and throat temperature. The current effort continues this work by including the nozzle section to investigate the impact it has upon the flow structure, in particular how the combusting shear layer reacts to disturbances reflected back into the chamber by the nozzle. The influence of modeling fidelity on rocket performance parameters will also be examined. How the values of throat temperature, injector lip temperature, characteristic velocity, and specific impulse vary as the engine is modeled as a 2-D or 3-D problem, obtaining both steady and time-averaged solutions is of significant importance to rocket engine designers and developers.

References

1. Archambault, M. R., & Peroomian, O., "Three-Dimensional Simulations of a Gas/Gas, Hydrogen/Oxygen Engine," AIAA 2003-0314, 41st AIAA Aerospace Sciences Meeting & Exhibit, Reno, NV, Jan. 2003.

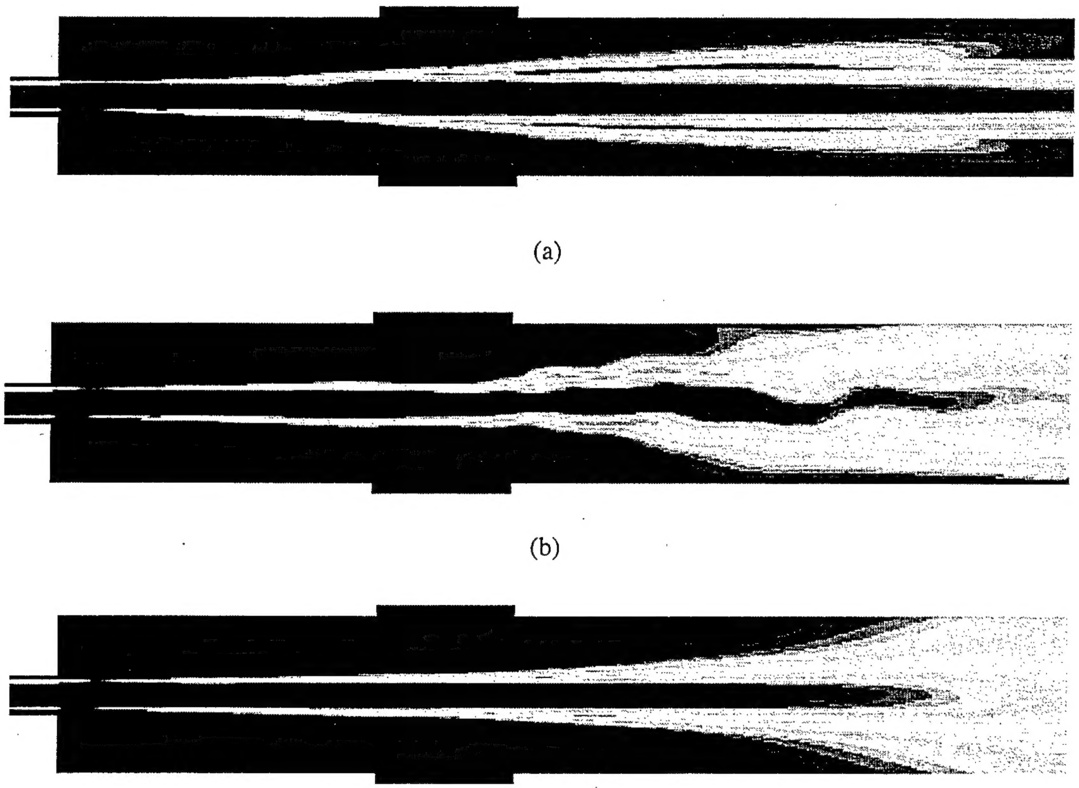
2. Archambault, M. R., Talley, D. G., & Peroomian, O., "Computational Analysis of a Single-Element, Shear-Coaxial, GH_2/GO_2 Engine," AIAA 2002-1088, 40th AIAA Aerospace Sciences Meeting & Exhibit, Reno, NV, Jan. 2002.

3. Moser, M. D., Merenich, J. J., Pal. S., & Santoro, R. J., "OH-Radical Imaging and Velocity Field Measurements in a Gaseous Hydrogen/Oxygen Rocket," AIAA 93-2036, 29th AIAA/SAE/ASME/ASEE Joint Propulsion Conference & Exhibit, Monterey, CA, June 1993.

4. Foust, M. J., Deshpande, M., Pal, S., Ni, T., Merkle, C. L., & Santoro, R. J., "Experimental and Analytical Characterization of a Shear Coaxial Combusting GO_2/GH_2 Flowfield," AIAA 96-0646, AIAA 34th Aerospace Sciences Meeting & Exhibit, Reno, NV, Jan. 1996.

5. Schley, C. –A., Gagemann, G., Tucker, P. K., Venkateswaran, S., & Merkle, C. L., "Comparison of Computational Codes for Modeling Hydrogen-Oxygen Injectors," AIAA 97-3302, 33rd AIAA/ASME/ SAE/ASEE Joint Propulsion Conference & Exhibit, Seattle, WA, July 1997.

6. Archambault, M. R., & Peroomian, O., "Characterization of a Gas/Gas, Hydrogen/Oxygen Engine," AIAA 2002-3594, 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Indianapolis, IN, July 2002.



(a)

(b)

(c)

Figure 1. OH concentration contours from 3D (a) steady, (b) instantaneous, and (c) averaged time-accurate solutions.

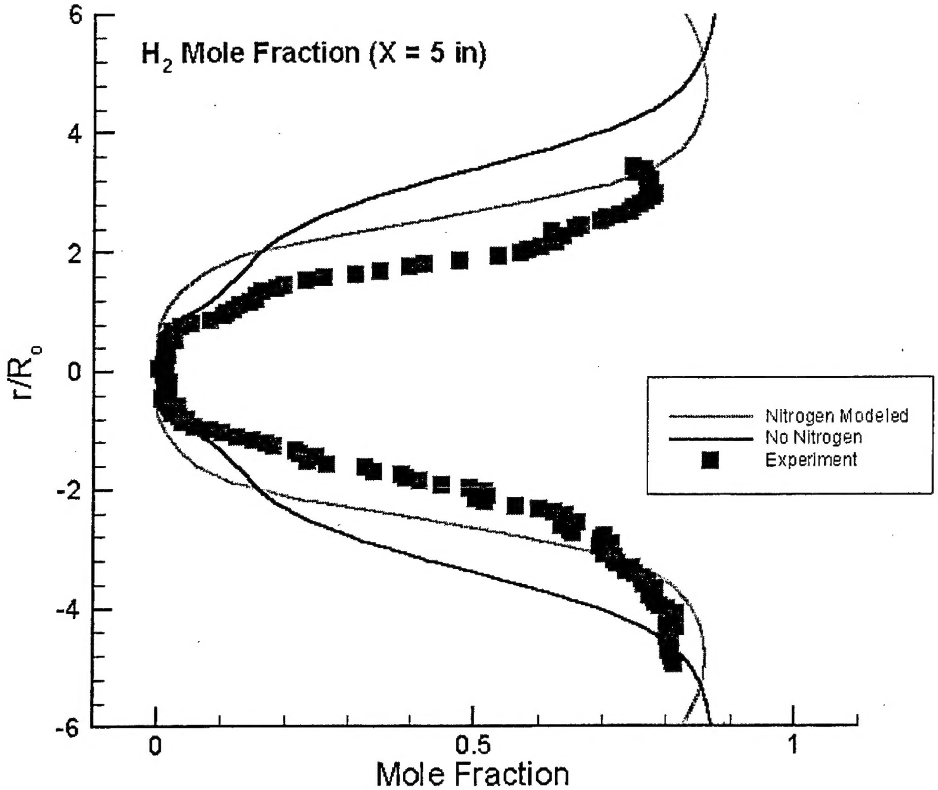


Figure 2. Hydrogen profiles from 2D calculations comparing the difference with and without the experimental nitrogen curtain purge.